Combined Density and Speed of Sound Measurements for Two (Methane + Nitrogen) Gas Mixtures

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The main objective of this research is to determine experimentally a complete set of thermodynamic properties over wide ranges of temperature and pressure for a number of key methane-rich gas mixtures. The results of the study will be of importance to current efforts aimed at constructing improved global equations of state for hydrocarbon mixtures that will be capable of meeting custody-transfer standards of accuracy for compressed natural gas.

A key feature of our work is that both $p\rho T$ and caloric properties have been measured for the same mixtures. Highly-precise measurements of gas density ρ were performed using a single-sinker magnetically-coupled buoyancy balance located at the University of Valladolid; this instrument is capable of achieving an uncertainty of approximately 0.025 per cent. The speed of sound was measured in the same mixtures using the spherical resonator apparatus located at Imperial College, London; the results of those measurements have an uncertainty of about 0.01 per cent.

Results are presented for the mixtures $(1\text{-}x)CH_4 + xN_2$, with $x = 0.1$ and $x = 0.2$, in the temperature range 240 K to 400 K with pressures up to 20 MPa. The mixtures were prepared gravimetrically in cylinders which were exchanged between the laboratories to ensure that exactly the same compositions are studied.

The combined results from both experimental techniques allow the evaluation of the isobaric and isochoric heat capacities of the fluids and, indeed, of all other observable single-phase thermodynamic properties. By extending both sets of experimental measurements over the entire ranges of temperature and pressure studied, we have a degree of redundancy in the sense that the experimental information is more than sufficient to determine the full thermodynamic surface in the region investigated. The study has thereby a degree of in-built error checking.